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Comparative phenological evaluation of white wine vine varieties grown in Bulgaria

Сравнителна фенологична оценка на бели винени сортове лози отглеждани в България

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ABSTRACT

A comparative phenological evaluation of a group of 32 vine varieties for white wines has been carried out. It has been found through the application of cluster analysis, PCA and factor analysis that, depending on the duration of the separate phenophases and periods in days, the studied varieties are grouped into four clusters. The phenological indicators are transformed into three factors, with a different degree of influence on the grouping of varieties, which explain 74% of the total variation. The most important for the grouping of varieties are the phenophase berry growth, and the periods flowering – berry softening and berry softening – technological maturity. In order to increase the efficiency of selection, it is advisable to cross varieties for white wines characterized by optimal phenological parameters, and belonging to clusters most remote from each other.

Keywords: phenophase berry growth, periods flowering, cluster analysis, PCA-analysis

РЕЗЮМЕ

Извършена е сравнителна фенологична оценка на група от 32 сорта лози за бели вина. Чрез прилагането на клъстерен анализ, факторен анализ чрез PCA е установено, че в зависимост от продължителността на отделните фенофази и периоди в дни, изследваните сортове са групирани в четири клъстера. Фенологичните показатели се трансформират в три фактора с различна степен на влияние върху групирането на сортовете, които обясняват 74% от общата вариация. Най-важни за групирането на сортовете са фенофаза растеж на зърната, както и периодите цъфтеж – омекване на зърната и омекване на зърната – технологична зрялост. За да се повиши ефективността на селекцията, е препоръчително да се кръстосват сортове за бели вина, характеризиращи се с оптимални фенологични параметри и принадлежащи към най-отдалечени един от друг клъстери.

Ключови думи: фенофаза растеж на зърното, периоди на цъфтеж, клъстер анализ, PCA-анализ

INTRODUCTION

The phenological features of grape varieties are a very important agrobiological feature in their ampelographic characteristics, as well as in the scientific interpretation of the climate effect on the quality of grapes and wine produced. Vine phenology is a key component in vineyard planning (Köse, 2014). On a global scale, wine production is becoming an increasingly important economic activity (Jones, 2013). Knowledge about the differences in the phenology of individual grape varieties is essential for the introduction and cultivation of new varieties (Parker et al., 2013; Agakhanov et al., 2022; Kazakhmedov et al., 2022). A global model is known that can adequately predict the dates of budding and flowering of all varieties (Pina-Rey et al., 2021). Warming in the northern wine-growing regions of Central Europe has not yet led to sufficiently stable changes in the phenology of the grape plant to take serious measures to adapt it (Bernáth et al., 2021). But according to others (Rotaru and Colibaba, 2013), in recent years, changes in environmental factors have become more visible towards changes in the life cycle of the grape plant. The purpose of this study is to isolate groups of similar and phenologically different varieties for the production of white wines, which could be used in their cultivation, micro-zoning and selection work.

Sivcev et al. (2011) establish the interaction of phenotypical variations, components of yield for the widest spread wine varieties and external factors of the Danube region in central Serbia. The number of fruitful buds per vine for twenty-one varieties was the same, whereas the yield and the components of the yield were different. The growing season, from bud burst to full ripening of the grapevine and the sum of active temperatures for the same period, were of crucial importance.

The variability of the onset and the duration of phenological phases are greater between years for a single cultivar than among cultivars within individual years, meaning that climatic factors are more important than genetic characteristics of cultivars for phenological timing (Ruml et al., 2013).

MATERIALS AND METHODS

The object of the study are 32 local, introduced and newly created white wine grape varieties in the ampelographic assortment of the Department of Viticulture at the Agricultural University in Plovdiv. The experimental vines are grafted onto a Kober 5 BB rootstock and grown using a Moser training system. For five consecutive years, the duration in days of the phenophases of budding, flowering, berry softening, berry growth and periods of budding-flowering, flowering-berry softening, berry softening -technological maturity and budding-technological maturity of each variety was traced (Bulgarian Ampelography, 1990). Some of the individual phenophase and period data are not integers due to their representation as averages.

The identification of groups (clusters) of varieties with similar phenological characteristics was carried out using hierarchical cluster analysis by the Ward method and as a measure of proximity between clusters of quadratic Euclidean distance. The result of the clustering procedure is visualized using a dendrogram.

To test the statistical significance of the results obtained, principal component analysis (PCA) was used, including the KMO-Test (>0.5) and Bartlett's test (<0.05). The indicators that influence the distribution of some varieties into different clusters or the association of others are explained by the results of the applied factor analysis, which requires that the determinant of the correlation matrix obtained from the correlation coefficients between all indicators be a positive number. The factors were rotated using the Varimax method.

Mathematical processing of experimental data was carried out in the environment of the statistical software product SPSS 24 (Landau and Everitt, 2004).

RESULTS AND DISCUSSION

The phenological characteristics of the studied white wine vine varieties show that there is no pronounced variability of indicators within the entire group (Figure 1).

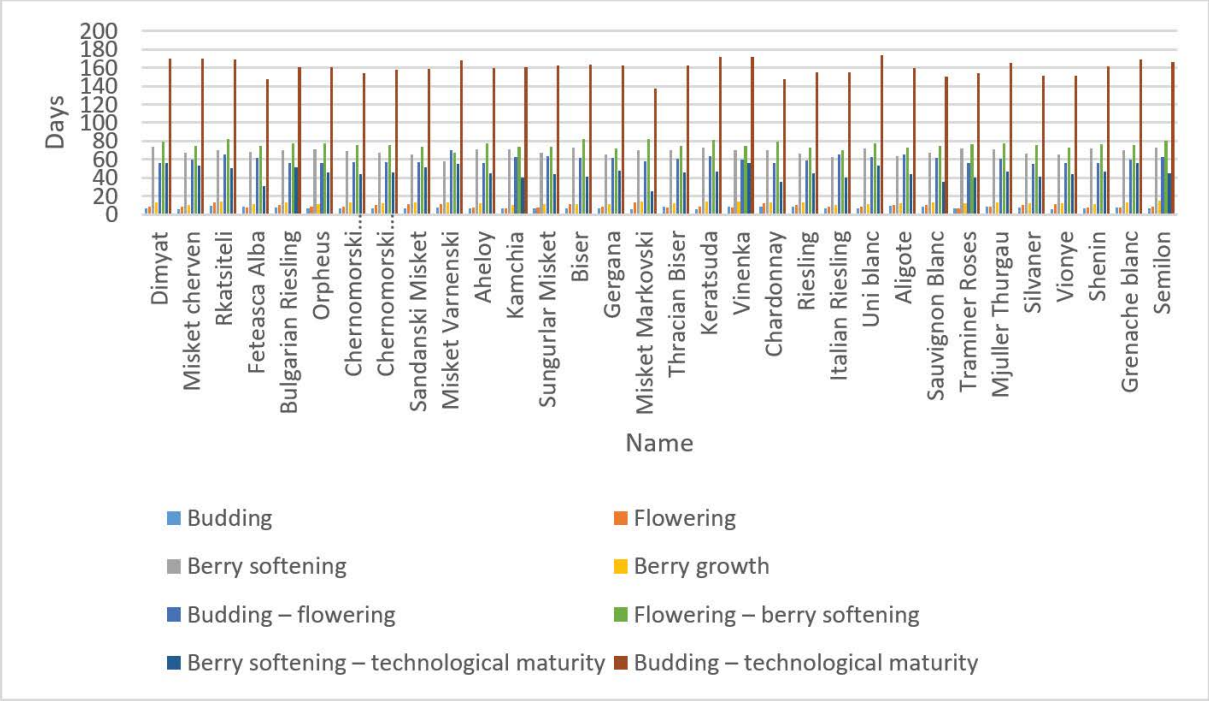

Figure 1. Phenological characteristics of the studied white wine vine varieties (days)

Most of the experimental varieties show approximately the same phenotypic response to all factors that affect the duration of individual phenophases. They are characterized by an average duration of budding of 7.4 days, flowering - 9.3 days, berry softening - 12.4 days, berry growth - 68.8 days, budding-flowering - 60 days, flowering-berry softening - 76 days, berry softening - technological maturity - 45 days, and budding - technological maturity - 160.2 days.

The studied white wine varieties are grouped into four clusters according to the degree of similarity of their phenological characteristics (Figure 2).

The first cluster consists of the varieties: Orpheus, Aheloy, Shenin, Thracian Biser, Mjuller Thurgau, Bulgarian Riesling, Misket Sandanski, Kamchia, Biser, Silvaner, Vionye, Chernomorski Brilyant, Chernomorski Eliksir, Riesling and Traminer Roses. They are characterized by moderate values of all phenological indicators. Varieties prevail in which the duration of budding is about 7.5 days, flowering - 9 days, berry softening - from 10 to 13 days, berry softening-technological maturity - from 40 days to 51 days. The period of budding-technological maturity lasts between 151 and 165 days.

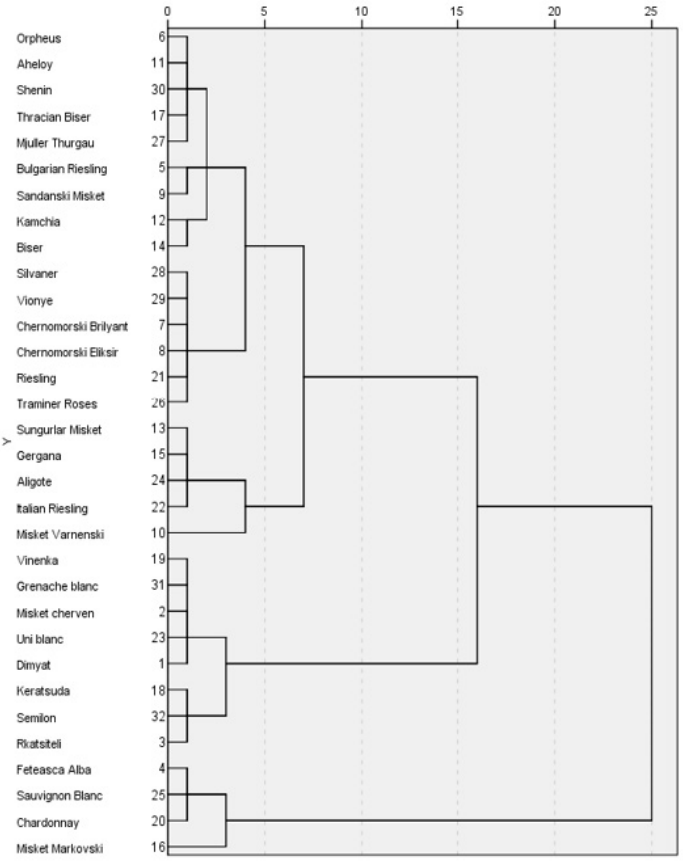

Figure 1. Dendrogram visualizing the grouping of the studied white wine vine varieties into clusters, in accordance with their phenological characteristics

Sungurlar Misket, Gergana, Aligote, Italian Riesling and Misket Varnenski form the second cluster. It is dominated by varieties that have a longer phenophase of budding - up to 10 days for Aligote, budding-flowering - up to 70 days for Misket Varnenski, a short period of flowering-berry softening - about 70 days, and the average duration of the budding-technological maturity period - about 160 days.

The third cluster includes the varieties Vinenka, Grenache blanc, Misket cherven, Uni blanc, Dimyat, Keratsuda, Semilon and Rkatsiteli. They have a short flowering - about 8 days, berry softening - about 12 days, a longer period of flowering-berry softening - up to 78 days in the Uni blanc variety, and a long period of budding-technological maturity - up to 174 days in the Uni blanc variety.

The fourth cluster includes Feteasca Alba, Sauvignon Blanc, Chardonnay and Misket Markovski. They are distinguished by the maximum duration of the berry softening phenophase - up to 15 days in the Semilon variety, budding-flowering - up to 64 days in Keratsuda, as well as the longest flowering-berry softening period, varying between 75 and 82 days.

In accordance with the data from the application of the principal component analysis (PCA), the studied indicators are transformed to three factors, and the strength of the influence of each one of them in the presented clustering is different (Table 1).

From the maximum possible number of eight components (studied indicators), the analysis is presented up to the third of them, since cumulatively they explain 74% of the total variation. The first one includes: berry growth, budding-flowering, flowering-berry softening and explains 27% of the total variation. The second one consists of berry softening-technological maturity and budding-technological maturity and explains 26% of the variation. The third one involves budding, flowering, berry softening and explains 21%.

Considering the values of the factor weight of each phenological indicator, it can be concluded that the phenophase of berry growth and the periods of flowering-berry softening and berry softening-technological maturity are the most important factors, when grouping varieties.

Table 1. Factor matrix for the transformation of phenological indicators of the studied white wine grape varieties

Indicator	Component 1	Component 2	Component 3
Budding	-0,196	0,097	0,626
Flowering	-0,075	-0,338	0,742
Berry softening	0,348	0,094	0,788
Berry growth	0,935	0,164	-0,126
Budding – flowering	-0,553	0,368	0,258
Flowering – berry softening	0,917	-0,034	0,225
Berry softening – technological maturity	-0,062	0,900	-0,001
Budding – technological maturity	0,061	0,982	-0,066
Percentage of total variation	27	26	21
Cumulative percentage of total variation	27	53	74

The transformation of the studied indicators to three factors determines their projection in a three-dimensional projection space (Figure 3). The factor weight values presented in Table 1 determine the location of the components in the respective quadrants and relative to the three coordinate axes. Berry growth and flowering-berry softening have the maximum weight and form the first component, which explains their location on the right side of the presented graphic image.

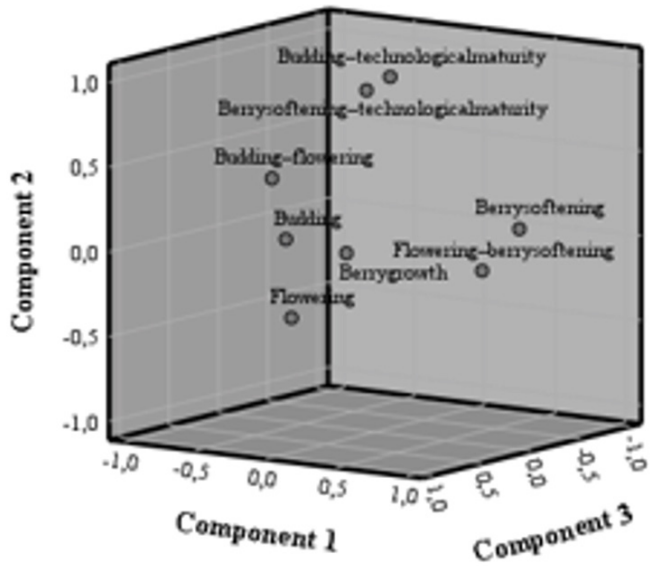

Figure 3. Projection of the studied phenological indicators in three-dimensional space

CONCLUSIONS

All phenologically studied vine varieties for the production of white wines are grouped into four clusters. The first one consists of varieties characterized by moderate values of all indicators. The second one includes varieties with a longer phenophase of budding, budding-flowering, and characterized by a short period of flowering-berry softening and an average duration of budding-technological maturity. The third one involves varieties characterized by short flowering and berry softening, a longer period of flowering-berry softening and a long period of budding-technological maturity. The fourth one contains varieties that have the maximum duration of the phenophase of berry softening, budding-flowering and the longest period of flowering-berry softening. The studied phenological indicators are transformed into three factors that have different strength of influence on the grouping of varieties, and they cumulatively explain 74% of the total variation. The first one includes: berry growth, budding-flowering, flowering-berry softening and explains 27% of the total variation. The second one involves berry softening - technological maturity and budding - technological maturity - 26%. The third one contains budding, flowering, berry softening - 21%. The phenophase of berry growth and the periods of flowering-berry softening and berry softening-technological maturity have the biggest impact when grouping varieties. In order to increase the efficiency of breeding work, it is advisable to cross varieties for the production of white wines, which are characterized by optimal phenological characteristics and belong to clusters located as far as possible from each other.

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